FUEL PROCESSING SYSTEM AND METHOD OF PURGING A FUEL PROCESSING SYSTEM

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to fuel processing systems and methods of purging them. In particular, the present invention relates to methods and systems for purging employing a purge gas comprising an inert gas and hydrogen.

Description of the Related Art

Fuel processing systems are used in many industries for converting a fuel into a hydrogen-rich reformate. For example, fuel cell electric power generation systems employing fuels such as natural gas or methanol, for example, will employ a fuel processing system for converting the fuel to a hydrogen stream usable by the fuel cell stack.

Typical fuel processing components include reformers, such as steam reformers, for example, and may also include shift reactors and/or selective oxidizers. On shutdown, fuel processing systems are typically purged of reactant gases, including residual fuel, reformate and other reaction products, to reduce deterioration of the components that can occur. The presence of reactants at lower temperatures can result in carbon deposition and/or water condensation on the catalyst bed(s) of the component(s) and carbonyl formation, for example.

Purging is typically performed using an inert gas stream, such as steam and/or nitrogen. At normal operating temperatures for steam reformers employing nickel catalysts (above 700 °C), steam purging causes the oxidation of nickel to nickel oxide (NiO). In addition, depending on the catalyst formulation, inactive spinel formation is also a concern.

On start-up, the catalyst is usually reduced again to nickel. Where spinel formation is a concern, catalyst activity may be recovered by operation at higher

temperatures with introduced hydrogen. However, there is concern that repeated oxidation and reduction of the catalyst leads to premature degradation. This is particularly a concern for fuel cell power generation systems in intermittent use applications because of repeated start-stop cycles. Accordingly, the use of steam purging in applications where the fuel processing system is frequently started and shut down is less than desirable.

Conventional fuel cell electric power generation systems typically employ pressurized nitrogen supplied from a nitrogen gas cylinder for purging. This approach undesirably increases the size and weight of the overall electric power generation system and requires maintenance to exchange an empty gas cylinder with a new one. Further, the operating cost of the electric power generation system is increased due to the expense of the inert gas supply. And, as with steam purging, there may be trace levels of oxygen in the steam reformer that can oxidize the catalyst as well.

It would be desirable to purge a fuel processing system without exposing nickel-based steam reforming catalysts to repeated reduction and oxidation cycles. It would also be desirable to reduce or avoid the use of pressurized nitrogen tanks for purging such fuel processing systems.

BRIEF SUMMARY OF THE INVENTION

A method of purging a fuel processing system comprising a steam reformer having a catalyst comprising nickel is provided. In one embodiment, the present method comprises supplying a purge gas to the steam reformer, the purge gas comprising an inert gas and hydrogen.

A fuel processing system is also provided, the present system comprising: a steam reformer having a catalyst comprising nickel; means for supplying a purge gas at least to the reformer; and, a hydrogen supply for supplying hydrogen to the purge gas.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Figure 1 is a plot of ln K against 1/T, for the equilibrium constants relating to the formation of nickel oxide (K_1) and the formation of water from hydrogen and oxygen (K_2).

Figure 2 is a plot of the calculated activity of NiO in the presence of the different purge gas mixtures according to the present method within a temperature range of 400 °C to 900 °C.

DETAILED DESCRIPTION OF THE INVENTION

A method of purging a fuel processing system comprising a steam reformer having a catalyst comprising nickel is provided. In one embodiment, the present method comprises supplying a purge gas to the steam reformer, the purge gas comprising an inert gas and hydrogen.

A fuel processing system is also provided, the present system comprising: a steam reformer having a catalyst comprising nickel; means for supplying a purge gas at least to the reformer; and, a hydrogen supply for supplying hydrogen to the purge gas.

Steam reformers typically have an operating temperature range of about 400 °C to about 900 °C. Thus, at least initially, purging of the reformer occurs at these temperatures. As mentioned above, steam has been used as a purge gas. However, in this temperature range steam may oxidize catalysts such as steam reforming catalysts. Repeated oxidation and reduction of the catalyst may adversely impact its activity and/or lifetime, particularly in applications where the duty cycle of the fuel processing system is relatively short.

The oxidation of nickel in steam reforming catalyst, in the presence of steam, is governed by the following reactions.